OBSERVATIONS ON SOME WEST AMERICAN THERMAL ALGÆ.

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(WITH PLATES VIII–X)

IT is the purpose of this paper to present an annotated list, with drawings, of thermal algæ, based on collections made in several western localities during the past two years.

Collection no. 1 was made by the writer in Yellowstone National Park during June and July of 1896. Specimens were preserved in formalin and a quantity of each kind was also dried. The natural color of the growths *in situ* was compared with the plates in Saccardo's *Chromotaxia*, ed. 2, 1894.

The hot waters of the Park are either calcareous, as at Mammoth Hot Springs, or contain silica in solution, as at Norris, Lower, Middle, and Upper Geyser Basins. Travertine results from the growth of algæ in calcareous waters, and siliceous sinter in siliceous waters.

Collection no. 2 was made by the writer from warm springs at Salt Lake City, Utah, in July 1897.

Collection no. 3 was made by the writer from the Natural Sulphur Spring at Banff, Alberta, during the month of August 1897. The warm springs of Banff are used for bathing purposes. They are situated on high ground and most of the overflow is carried away by means of ditches, several feet deep, which lead down the steep hillside. Here the water accumulates on a level space and forms a shallow but quite extensive pond or lake. Some of the overflow escapes underground for a short distance and appearing again halfway down the hill spreads out in terraces and finally joins the stagnant water below. These sheets of water have naturally lost much of their heat, but they are still tepid and support a luxuriant growth of Chara and other

Chlorophyceæ, numerous species of mosses, equisetum, etc. The water in the ditches is only a few inches in depth, but has a swift current. By the time it has reached the base of the hill it is but slightly warm. The older portions of the "formation" on this hillside are composed of travertine produced by mosses.

Collection no. 4 was made by Mr. Walter Harvey Weed in Yellowstone National Park during 1897, and sent to me for determination. This adds new localities and several new forms to the list.

Collection no. 5 was made by Professor Francis E. Lloyd from hot springs in the region of the Cascade mountains, Oregon.

OEDOGONIUM CRENULATO-COSTATUM Wittr. var. AUREUM Tild. Am. Alg. Cent. II. no. 123. 1896. (*Pl. VIII, figs. 1, 2, 3.*)

Oogonia single or 2–3-seriate, elliptical or oboviform, opening by a pore in upper portion; oosperms nearly filling the oogonia, exospore smooth, endospore crenulate-costate, reticulate, orange-colored (*aurantiacus*); supporting cell similar to the other vegetative cells; filament of male plant slightly smaller than that of female; antheridial cells alternating with vegetative cells, 2–5-celled; terminal cell (sometimes an oogonium) obtuse; vegetative cells 10–13 μ in diameter, 3.5–6 times longer; oogonia 32–37 × 40–50 μ; oosperms 29–30 × 38–39 μ; antheridial cells 10 × 10 μ. In overflow from small hillside spring. Water tepid. Between Middle and Upper Geyser Basins, Yellowstone National Park. J. E. T. 2 Jl 1896.

The endospore in this plant is crenulate-costate, but with transverse as well as longitudinal costae; the dimensions of the vegetative cell differ a little from those given in the type description; the mature oospores are bright orange-colored, a character not mentioned in the specific description; it occurs in thermal, flowing water, instead of cold stagnant water. In all other respects the variety is similar to the species.

An Oedogonium was also found in the tepid terrace waters at Banff, but as it was not in fruit the description is omitted. For a like reason a species of Zygnema growing with it is not described.

HORMISCIA FLACCIDA (Kg.) Lagerh. var. CALDARIA (Kg.) Hansg. Prodr. 61. 1886–1888 and in Flora 265. 1888. Tilden. Am. Alg. Cent. II. no. 130. 1896. (*Pl. VIII, figs. 4, 5.*)

Stratum dull green, soft, in long strings, dark green in the current, light green scum in the standing water; vegetative cells 5–7.5 μ wide, 0.5–2 times as long as the diameter.

In water from hot spring flowing down a grassy bank. Temperature 23° C. Norris Geyser Basin, Yellowstone National Park. J. E. T. 26 Je 1896.

This form seems to agree almost equally well with the above variety and with *H. subtilis* (Kg.) De Toni var. *thermarum* (Wartm.) Rabenh. Like the former, it occurs in soft somewhat lubricous masses. Its measurements correspond exactly, if the cells undergoing division be excepted. A filament made up entirely of mature cells would resemble Kützing's figure in *Tab. Phyc.* 3: *pl. 32, f. 3.* 1853. On the other hand, its habitat seems to accord better with the latter variety. When compared with Rabenhorst's Algen Sachs. no. 655 (placed here by De Toni) there is found to be no special difference in appearance. The diameter of Rabenhorst's specimen is slightly greater, perhaps, and the length of the cells, while in general 1–1.5 times the diameter, in many cases is twice the diameter. It would then appear that the Yellowstone plant agrees with the description of one species and an authentic specimen of another species as these are offered in De Toni's *Sylloge Algarum.* If forma *crassior* Hansg. of var. *thermarum* be taken into account, there would seem to be no objection to making a single variety of the two, especially as they belong to species so nearly related. In that case, according to the rule of priority, the plant would take the above name.

CONFERVA MAJOR (Kg.) Rabenh, forma **ferruginea**, n. f. (*Pl. VIII, figs. 6, 7, 8.*)

Brownish (*ferrugineus, fulvus*); filaments encrusted with ferric-oxide (Fe_2O_3), sometimes in narrow bands, generally forming extensive coatings; cells 13–20 μ in diameter, twice the diameter in length, after division equaling the diameter.

In acid waters of overflow. Temperature 74° C. "These algæ are in part coated with Fe_2O_3 on the margins of the pools." Echirus Geyser. W. H. W. 1897.

The width of the filament in the form is somewhat narrower than that of the species. The specimen shows well the "letter H" appearance of the ruptured membrane which De Toni makes a generic character.

CONFERVA MAJOR (Kg.) Rabenh. forma **gypsophila,** n. f. (*Pl. VIII, figs. 9, 10, 11.*)

Forming white or yellowish masses; filaments encrusted with crystals of gypsum; cells 10–20 μ in diameter, twice as long as wide, after division equaling in length the diameter; cell contents granular, colorless; cell membrane thick.

Lying near vent of spring. Temperature 66° C. Norris Geyser Basin, Yellowstone National Park. J. E. T. 27 Je 1896.

This plant likewise differs from the species in having a narrower filament. Little spiny or lobed masses of gypsum, a centimeter in thickness, are found entwined with the threads.

MICROSPORA AMOENA (Kg.) Rabenh. forma **thermalis,** n. f. (*Pl. VIII, fig. 12.*)

Dark green, stringy; cells cylindrical, 11–14 μ in diameter, before division 2–3 times as long as wide, after division equal to or a little more than the diameter in length; membrane smooth, delicate, firm; cell contents finely granular, bright green; filaments not constricted at septations.

(*a*) Lying in overflow from spring. Temperature 41° C. Frying Pan Basin, Yellowstone National Park. J. E. T. 7 Jl 1896.

It is difficult to decide whether this plant should be classed as a Conferva or a Microspora, as the structure of the chloroplastids could not be made out. It is placed here provisionally. Its size is not as great as that of the species.

(*b*) A second gathering, slightly different in color, was

vegetative green becoming yellowish. It occurred in soft masses on bottom of a spring. Temperature 38° C. Locality and date same as above.

In the first collection small prickly masses of mineral formation, probably gypsum, also occurred. *Chroococcus varius* was present in great quantity. The second collection contained Protococcus cells.

Microspora Weedii, n. sp. (*Pl. VIII, fig. 13.*)

Cespitose-floccose, dark green in denser parts, pale bluish-green in thinner portions; vegetative cells cylindrical, sometimes a little constricted at the septations, 7–9 μ in diameter, before division 0.5–3 times longer than diameter; membrane homogeneous, hyaline, thin.

(*a*) Bright green. Forms jelly on slope. Temperature 49° C. Growler, Norris Basin, Yellowstone National Park. W. H. W. 1897.

The peculiar bluish-green color is no doubt caused by the action of the formalin upon the plant, but it is worth noting since it has not been observed in other formalin material of the green algæ. The plant probably is nearest to *M. abbreviata* (Rabenh.) Lagerh. but differs from it in being entirely free from the ferruginous color, in having a thin membrane, and in its habitat.

RHIZOCLONIUM HIEROGLYPHICUM (Ag.) Kg. var. **atro-brunneum**, n. var. (*Pl. VIII, figs. 14, 15, 16, 17.*)

In long strings, dark brown (*fuligineus*); normal vegetative cells 15–22 μ in diameter, less than once as long to three times longer than wide, very variable in size in the same filament, rarely producing short rhizoids; cell contents (examined when fresh) dark brown, granular.

(*a*) In shallow water, plastered to surface of ground, most luxuriant in slow current. In overflow, through grass, of hot spring on bank above. Temperature 24° C. Norris Geyser Basin, Yellowstone National Park. J. E. T. 27 Je 1896.

(*b*) Dull brown filaments. In overflow channel. Temperature 38° C. Near Constant Geyser, Norris Geyser Basin, Yellowstone National Park. W. H. W. 1897.

Nearly every filament of my specimen contains one or more distorted cells. These are sometimes swollen to several times the size of the normal cells, and in general have a thicker wall. It was first thought that the plant might be identical with or at least related to *Hormiscia ? thermalis* Crouan (in Mazé and Schramm *Algues de la Guadeloupe* ed. 2, p. 42). But since access cannot be had to this specimen and the data furnished in the type description (De Toni *Sylloge Algarum* **1**:171. 1889) is confined to a statement of the color and habitat—"Atro-brunnea. Hab. ad muros lateritios in aquario thermali (36° C) ad 'Dolé' insulae Guadeloupensis (Coll. n. 351. II série)"—it is thought best to place it under the above name.

Mr. Weed's specimen appears to be exactly the same plant. It shows, however, almost no trace of the distortion and no lateral projections could be found.

PROTOCOCCUS BOTRYOIDES (Kg.) Kirchn. forma **caldarius,** n. f. (*Pl. VIII, fig. 18.*)

Aquatic, vegetative or yellowish green; cells globose, 4–6 μ in diameter, for the most part solitary; membrane thin, homogeneous, hyaline; cell contents homogeneous, vegetative green.

(*a*) On bottom of spring. Temperature 38° C. With *Microspora amoena*, forma *thermalis*. Frying Pan Basin, Yellowstone National Park. J. E. T. 7 Jl 1896. Agrees with species with exception of habitat.

CALOTHRIX THERMALIS (Schwabe) Hansg. Beiträge zur Kenntniss der Böhmisch. Thermalalgenflora (Oesterr. Bot. Zeitschrift **34**:279. 1884. (*Pl. IX, figs. 1, 2, 3, 4, 5.*)

Stratum soft, dark seal brown or black; filaments crowded, flexuose, 10–13 μ, rarely 18 μ in diameter, thickened at base; sheath in young plants thick, lamellated, colorless, in older plants wider, brownish; trichome in young plants 5–9 μ in

diameter, bright blue-green, granular, distinctly articulated or rarely with dissepiments not visible, sometimes moniliform, in older plants paler aeruginous, much narrower, with shorter articulations, not plainly visible, with apex tapering to a hair-point; articulations equal in length to diameter, but often, particularly in younger plants, twice the diameter in length; heterocysts 1–2 seriate, basal or intercalary, very variable in size and shape.

(*a*) Overflow of channel of geyser. Temperature 49–54.5° C. Spasmodic Geyser, Upper Geyser Basin, Yellowstone National Park. W. H. W. 1897.

(*b*) Forming cedar-colored fur on overflow channel of geyser. Old Faithful Geyser, Upper Geyser Basin, Yellowstone National Park. W. H. W. 1897.

(*c*) With other algæ in rivulets. Temperature 49–50° C. Fountain Hotel Geyser Basin, Yellowstone National Park. J. E. T. 29 Je 1896.

(*d*) Very common in colder portions of overflows. Varying in color from *umbrinus* to *castaneus* and *fuligineus*. Growing in small islands or forming smooth surfaces. Temperature 34° C. Emerald Pool, Upper Geyser Basin, Yellowstone National Park. J. E. T. 3 Jl 1896.

Mr. Weed has frequently mentioned this plant, but under other names. He describes an algal sinter which, "forming in the overflow channels of many of the geysers of the Upper Basin, is finely fibrous, consisting of layers one-sixteenth of an inch to half an inch thick, each stratum resembling a very fine thick white fur. This sinter is formed by the growth of the little algæ, *Calothrix gypsophila* Kg., or the young form, *Mastigonema thermale*, the latter olive-colored."[1] Again, "the proportion of algal sinter forming the deposits about the Geyser Basins is strikingly shown in the following section of the strata forming the wall of Excelsior crater. . . . . In this section 50 per cent. consists of the fibrous sinter formed by

[1] Formation of travertine and siliceous sinter by the vegetation of hot springs, U. S. Geol. Surv. 9th Ann. Rep., 665. 1889.

Mastigonema."[2] He describes a specimen of New Zealand sinter from the hot waters of Rotorua, and notes that "the exact counterpart of this sinter occurs at many localities in the geyser basins of the Yellowstone, notably about the Prismatic Spring and the overflow channels of Old Faithful. It forms over one-half of the section of fifteen feet of sinter exposed in the crater walls of the Excelsior Geyser. This sinter we know to be the result of the growth and incrustation of little algæ, which form a cedar-colored (*Calothrix gypsophila* Kg.), or olive (*Mastigonema thermale*) slippery coating on the surface of the deposit. The analogy is so perfect that there seems but little doubt that the New Zealand sinter is the result of the growth of similar or allied algæ."[3]

The plant *Calothrix gypsophila* (*Dichothrix gypsophila*) is a lime-encrusting form. I have not personally observed it up to this time in material from Yellowstone Park. *Mastigonema thermale*, a synonym of *Calothrix thermalis*, does not characteristically secrete lime. The Yellowstone form has only been found in siliceous waters. It differs slightly from the type description of Bornet and Flahault in that the articulations, instead of being "diametro æqualibus vel usque ad 3-plo brevioribus" are equal to up to three times *longer* than the diameter. It agrees, however, in this character with Hauck and Richter's specimen in *Phyk. univ.* no. 742, which was collected from the Carlsbad springs in 1894 and 1895 by S. Schmula. Therefore the two forms named by Mr. Weed are considered to be the same plant.

The above species has been described from Carlsbad, Germany, by Schwabe, Kützing, and Cohn.

RIVULARIA HAEMATITES (DC.) Ag. Syst. Alg. 26. 1824. (*Pl. IX, figs. 6, 7, 8, 9.*)

Thallus forming a hard calcareous crust, 5^{mm} in thickness; filaments dense, 7.8–11.7μ in diameter; sheath narrow, hyaline, rarely brownish; trichomes 3.9–5.2μ in diameter, with lower

[2] Loc. cit. [3] Loc. cit. 674.

cells one to two times longer than wide, middle cells two to three times longer than wide, and upper cells in general subquadrate, with apex prolonged into a thread; cell contents granular.

Forming a calcareous crust on bottom of ditch. Natural Sulphur Springs, Banff, Canada. J. E. T. 13 Ag 1897.

This growth occurs toward the lower end of the ditch where the water is slightly warm and the current very swift. The general appearance and microscopic characters agree very well with authentic specimens in the Minnesota herbarium.

HAPALOSIPHON MAJOR Tild. Am. Alg. Cent. II. no. 167. 1896. (*Pl. IX, figs. 10, 11, 12, 13.*)

Stratum widely expanded, bright aeruginous in color; filaments sheathed, branched, composed of cells sometimes cylindrical, 3–6μ in width, showing no dissepiments, or divided into short somewhat quadrate to very long cells, sometimes globose up to 11μ in diameter; branches single or geminate, sometimes geniculate; heterocysts intercalated, oblong, cask-shaped, about 8μ in width, one to two times as long as wide.

(*a*) Completely coating bed of very swift mountain rivulet, at vent of hot spring. Temperature of spring 61° C. Algal growth begins here and disappears at a distance of fifty-five feet from spring where temperature is 51° C. Most luxuriant growth thirty-five feet from spring at temperature of 54° C. Mountains near Lower Geyser Basin, Yellowstone National Park. J. E. T. 28 Je 1896.

(*b*) In hot spring. Temperature 55° C. Cascade mountains, lat. 45° 20′. Francis E. Lloyd, 1895.

The filaments of *H. major* are nearly twice the diameter of those of *H. laminosus*. An important character of the latter plant is its habit of forming crystals of lime, according to Cohn, who studied the plant at Carlsbad. The Yellowstone species occurred in siliceous waters only, at least it was not discovered at Mammoth Hot Springs, where the waters contain calcium carbonate.

SCHIZOTHRIX CALCICOLA (Ag.) Gomont, Monographie des Oscillariées, Ann. Sci. Nat. (Bot.) VII. **15**: 307. *pl. 8, figs. 1–3.* 1892. Tilden, Am. Alg. Cent. II. no. 180. 1896. Described in BOT. GAZ. **24**: 197, 198. *pl. 8, figs. 3, 4.* 1897.

SYMPLOCA THERMALIS (Kg.) Gomont. Monogr. des Oscill. in Ann. Sci. Nat. (Bot.) VII. **16**: 114. *pl. 2, figs. 15, 16.* 1892. (*Pl. IX, fig. 14.*)

Stratum dark aeruginous, widely expanded; filaments very rarely pseudo-branched, fragile, densely intricate, crisp; sheath thin; trichomes pale aeruginous, not attenuate at the apex, 1.5–2 μ in diameter; articulations two to three times longer than the diameter of the trichome, rarely somewhat quadrate, 2–5 μ in length; protoplasm homogeneous, rarely containing granules; dissepiments visible; apical cell rotund; no calyptra.

(*a*) Forming extensive layers or knob-like masses on bottom of ditch. Natural Sulphur Springs, Banff, Canada. J. E. T. 13 Ag 1897.

The appearance of this growth was peculiar. The rich blue-green surface of the layer was marked off into broad ridges of a lighter color, making it resemble very much the ripple-marks left in sand by waves. The filaments are nearly prostrate, taking the direction of the current. It occurred in the same ditch with *Rivularia haematites*, but farther up the hill. The water here is warmer and the current not quite so swift.

PHORMIDIUM LAMINOSUM (Ag.) Gomont. Essai de Class. des Nostocacées homocystées in Morot, Journ. de. Bot. **4**: 355. 1890. Tilden, Am. Alg. Cent. II. no. 181. 1896. (*Pl. IX, fig. 15.*)

Stratum mucilaginous, yellowish, bluish, or bright green, or forming a scurfy, thin, brittle scum with a soft gelatinous cushion underneath; filaments flexuous, densely intricate; sheath not visible; trichomes pale aeruginous, not constricted at joints, with apex straight, briefly attenuate and not capitate, 1.6μ in diameter; articulations longer than the diameter of the trichome,

2.5–3.2μ in length; dissepiments marked by granules; apical cell acutely conical; no calyptra.

(*a*) In overflow water of spring where the old formation makes a hard, billowy or terraced incline, the algæ extend down the incline for a distance of twenty feet, forming wide ribbons of green alternating with bands of pink, yellow, white, and a darker green. Temperature of spring 91° C. The algal growth occurs at a temperature of 51–55° C. Ribbon Spring, Norris Geyser Basin, Yellowstone National Park. J. E. T. 27 Je 1896.

(*b*) In small shallow spring, expanding at top in leaf-like masses, or tapering from bulbous head to a small tubular base. Temperature 55° C. Valley of Nez Perces creek, Lower Geyser Basin, Yellowstone National Park. J. E. T. 28 Je 1896.

(*c*) In grassy rivulet. Temperature 30° C. Mountain hot springs, Lower Geyser Basin, Yellowstone National Park. J. E. T. 28 Je 1896.

(*d*) Around edges of springs. Forming brown and green layers which turn gray or blackish out of the water. Temperature 63° C. Prismatic Lake, Middle Geyser Basin, Yellowstone National Park. J. E. T. 2 Jl 1896.

(*e*) Forming plumy strings, white or light yellowish in color. Temperature 75.5° C. Solitary Spring, Upper Geyser Basin, Yellowstone National Park. J. E. T. 3 Jl 1896.

(*f*) Forming whitish, scurfy, hardened, rather brittle scum on surface of still pool into which overflow runs. Temperature 41° C. Mammoth Hot Springs, Yellowstone National Park. J. E. T. 8 Jl 1896.

I found this species to be by far the most widespread and abundant of any alga in the hot waters of the park. Its habit of growth is extremely varied, so that it is not easily recognized. It is the only species, except *Spirulina major*, that, so far as I know, is found in both calcareous and siliceous waters in this region.

PHORMIDIUM LAMINOSUM (Ag.) Gomont, forma **Weedii,** n. f. (*Pl. IX, fig. 16.*)

Stratum aeruginous; filaments often strongly bent; sheath not visible; trichomes pale aeruginous, not constricted at joints, with apex sharply bent, briefly attenuate and not capitate, 2.5–3μ in diameter, the dissepiments generally distinct; articulations 1.5–2.5 times as long as the diameter; protoplasm commonly containing granules; dissepiments sometimes marked by granules; apical cell acutely conical; no calyptra.

(*a*) In overflow of channel. Temperature 49–54.5° C. With *Spirulina major*. Spasmodic Geyser, Upper Geyser Basin, Yellowstone National Park. W. H. W., 1897.

This plant is very near typical *P. laminosum*. The points of difference are that the filaments are slightly greater in diameter, the apex is almost invariably sharply bent and the dissepiments may or may not be marked by granules. Sometimes the entire cell contents are granular.

PHORMIDIUM TENUE (Menegh.) Gomont. Monogr. des Oscill. in Ann. des Sci. Nat. (Bot.) VII. **16**: 169. *pl. 4, f. 23–25*. 1892. Tilden, Am. Alg. Cent. II. no. 182. 1896. (*Pl. IX, fig. 17*.)

Stratum consisting of a thick firm mass, 10–40^{mm} in thickness, upper exposed surface honeycombed, the ridges being thin and papery, and easily crushed; in color surface showed a range between *ferrugineus* and *ochraceus*, the interior between *viridis* and *prasinus;* filaments very long, somewhat straight; sheath delicate; trichomes light aeruginous, straight, constricted at joints, the dissepiments themselves generally indistinct, with apex straight or sometimes bent, not capitate, 2–3μ in diameter; articulations in general 1.5–2 times the diameter, 3–6.4μ in length; protoplasm homogeneous; apical cell acutely conical or bluntly rounded; no calyptra.

Around edges of spring, not covered by water, but water flows in little streams through and around it. Temperature of water 33°C. Lower Geyser Basin, Yellowstone National Park. J. E. T. 29 Je 1896.

PHORMIDIUM RUBRUM Tilden, Am. Alg. Cent. II. no. 186. 1896. (*Pl. IX, fig. 18*.)

Stratum thin, scarlet (*miniatus*); filaments somewhat straight; sheath visible under high powers; trichomes fragile, frequently interrupted, neither attenuate nor curved, not constricted at joints, 1μ in diameter; articulations quadrate or a little longer than broad; dissepiments not or rarely visible.

In overflow from small hillside spring. Water tepid. Between Middle and Upper Geyser Basins, Yellowstone National Park. J. E. T. 2 Jl 1896.

This species is near *P. luridum* and *P. purpurascens*. From the former it differs in not having trichomes constricted at joints. From the latter it differs in not having strongly tortuous filaments nor granulated dissepiments. It is also to be distinguished from both by the color of the stratum and of the trichomes and the length of the articulations.

OSCILLATORIA PRINCEPS Vauch. Hist. Conferv. d'eau douce 190. *pl. 15, f. 2.* 1803. Tilden, Am. Alg. Cent. II. no. 187. 1896. (*Pl. IX, fig. 19.*)

Stratum dark green or black; trichomes 16–19μ in diameter; apex slightly attenuate and shortly arcuate; articulations 4.5–5.5μ long; protoplasm finely granulate; apical cell convex; calyptra none.

(*a*) Forming a black thick floating mass in mountain stream at vent of hot spring; gradually running out, and replaced by green at a distance of fifty feet from vent. Temperature five feet from spring 42°C., fifty feet from spring 38°C. Mountains near Nez Perces creek, Lower Geyser Basin, Yellowstone National Park. J. E. T. 28 Je 1896.

(*b*) Forming dark green velvety mass fringing edge of small mountain creek where a hot spring flows out just underneath the bank. Temperature of water one inch below surface 19°C. On surface 58° C. Near Emerald Pool, Upper Geyser Basin, Yellowstone National Park. J. E. T. 3 Jl 1896.

OSCILLATORIA TENUIS Ag. Alg. Dec. **2**:25. 1813. Tilden, Am. Alg. Cent. II. no. 190. 1896. (*Pl. IX, fig. 20.*)

Stratum black or purplish (*atro-violaceus*); filaments dilute

purplish-black (*atro-cyaneus*), straight or somewhat flexuous, constricted at the dissepiments, for the most part 8–13μ in diameter, not attenuate at apex, straight or but slightly arcuate at extremities; articulation 0.25–0.5 times as long as wide, 3–6μ long; protoplasm homogeneous; dissepiments sometimes granulose; apical cell conical, not capitate; no calyptra.

In small mountain spring in a bog, together with moss and watercress. Water tepid. Valley of Nez Perces creek, Lower Geyser Basin, Yellowstone National Park. J. E. T. 28 Je 1896.

OSCILLATORIA AMPHIBIA Ag. Aufzählung, etc. in Flora **10**: 632. 1827. (*Pl. IX, fig. 21.*)

Stratum aeruginous, red or orange colored; trichomes dilute aeruginous, straight or arcuate, fragile, not constricted at dissepiments, 1.5–2μ in diameter, arcuate for some distance at extremities, apex neither attenuate nor capitate; articulations two to three times longer than diameter of trichome, 3–4μ in length; dissepiments sometimes marked by two protoplasmic granules, sometimes not distinct; cell contents granular; apical cell rotund.

Forming lining in channel of spring. Above Beehive Geyser, Upper Geyser Basin, Yellowstone National Park. W. H. W. 1897.

The red and orange colors in this material are caused by the presence of bacteria.

OSCILLATORIA GEMINATA Menegh. Conspect. Algol. euganeæ. 9. 1837. Tilden, Am. Alg. Cent. II. no. 191. 1896. (*Pl. IX, fig. 22.*)

Stratum dark green, forming long plumy tufts; trichomes pale aeruginous, densely interwoven, very much constricted at joints, 3.2μ thick; apex straight, not attenuate nor capitate; articulations of unequal length, quadrate or longer than the diameter, 3.2–7μ long; protoplasm containing granules; dissepiments pellucid, not granulated; apical cell rotund; no calyptra.

Covering bottom of creek in swift current. Temperature

47.5°C. Near Upper Geyser Basin, Yellowstone National Park. J. E. T. 2 Jl 1896.

SPIRULINA MAJOR (Kg.) Phyc. Gener. 183. 1843. Tilden, Am. Alg. Cent, II. no. 193. 1896. (*Pl. VIII, fig. 19.*)

Forming a thin brittle scurfy scum, whitish on top; stratum dull green (*prasinus*); trichomes pale green, wound into somewhat straight, dense, very regular spirals with a diameter equaling 3μ, in thickness 1μ; turns contiguous.

(*a*) On surface of still pool into which overflow runs. Temperature 41°C. Mammoth Hot Springs, Yellowstone National Park. J. E. T. 8 Jl 1896,

(*b*) Overflow of channel of geyser. Temperature 49–54.5°C. Spasmodic Geyser, Upper Geyser Basin, Yellowstone National Park. W. H. W. 1897.

(*c*) Forming a whitish brittle scum in the hot water. Beck's Hot Springs. Salt Lake City, Utah. J. E. T. 7 Jl 1897.

This species is quite common in both the calcareous and siliceous waters of the Park. It is generally found with other algæ. I did not find any pure growths.

Spirulina caldaria, n. sp. (*Pl. VIII, fig. 20.*)

Stratum widely expanded, dark aeruginous; trichomes aeruginous, short, somewhat straight and stiff, forming a very lax spiral with a diameter of 1.5μ, 0.9μ in thickness; turns 3.2μ distant from each other.

(*a*) Forming thick richly colored strata on surface of hot water very near outlet of the springs. Natural Sulphur Springs, Banff, Canada. J. E. T. 13 Ag 1897.

SYNECHOCOCCUS ÆRUGINOSUS Næg. Einz. Alg. 56. 1849. Tilden. Am. Alg. Cent. II. no. 195. 1896. Described in BOT. GAZ. **24**: 198. *pl. 8. fig. 6.* S. 1897.

GLŒOCAPSA VIOLACEA (Corda) Rabenh. Fl. Eur. Algar. **2**: 41. 1865. Tilden. Am. Alg. Cent. II. no. 196. 1896. Described in BOT. GAZ. **24**: 198. *pl. 8. fig. 5.* S. 1897.

CHROOCOCCUS VARIUS A. Br. Rabenh. Alg. Eur. no. 2451 and 2452. Tilden. Am. Alg. Cent. II. no. 198. 1896. (*Pl. VIII, fig. 21.*)

Cells spherical, single or in small groups, 1.6–5.6 μ in diameter; cytoplasm pale aeruginous.

(*a*) On rocks. Near vent of geyser. Sometimes heated. Norris Geyser Basin. Yellowstone National Park. J. E. T. 27 Je 1896.

(*b*) With *Microspora amœna* var. *thermalis*, lying in overflow from spring. Temperature 41° C. Frying Pan Basin. Yellowstone National Park. J. E. T. 7 Jl 1896.

(*c*) Forming a green coating on floor of overflow channel. Temperature 49° C. Constant Geyser, Norris Geyser Basin. Yellowstone National Park. W. H. W. 1897.

(*d*) In acid waters. Green Spring. Between Norris Geyser Basin and Beaver Lake. Yellowstone National Park. W. H. W. 1897.

UNIVERSITY OF MINNESOTA.

EXPLANATION OF PLATES VIII–X.

PLATE VIII.

FIG. 1. *Œdogonium crenulato-costatum* Wittr. var. *aureum*. Filament of female plant showing twin oogonia containing oosperms.

FIG. 2. Filament of male plant with five antheridial cells.

FIG. 3. Apical cell of filament.

FIGS. 4, 5. *Hormiscia flaccida* (Kg.) Lagerh. var. *caldaria*. Filaments with cells of different lengths.

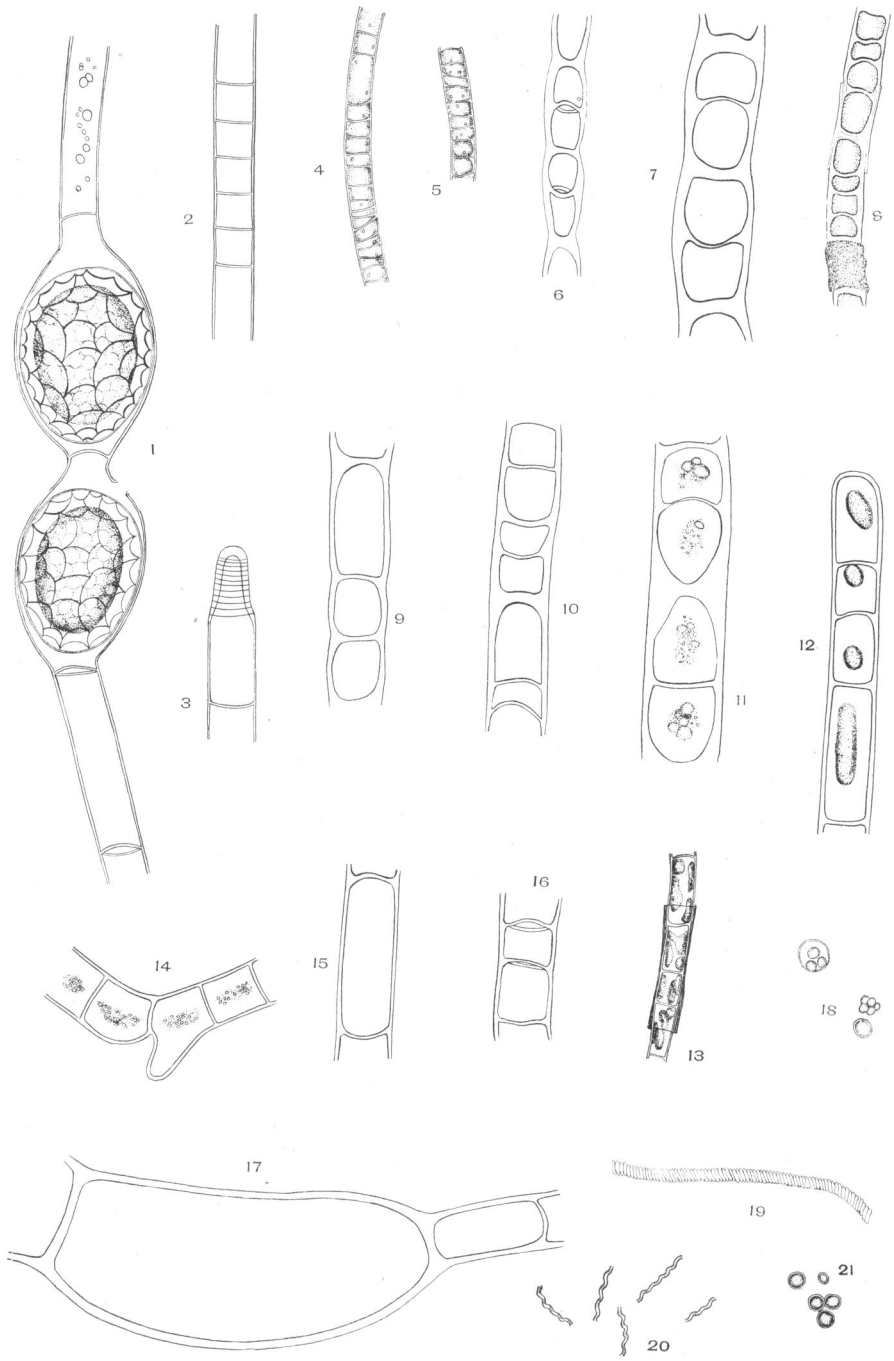
FIGS. 6, 7. *Conferva major* (Kg.) Rabenh. forma *ferruginea*. Filaments of empty cells showing relative thickness of old and new walls.

FIG. 8. Filament of same showing cell contents, incrustation of Fe_2O_3 and characteristic appearance of ruptured sheath.

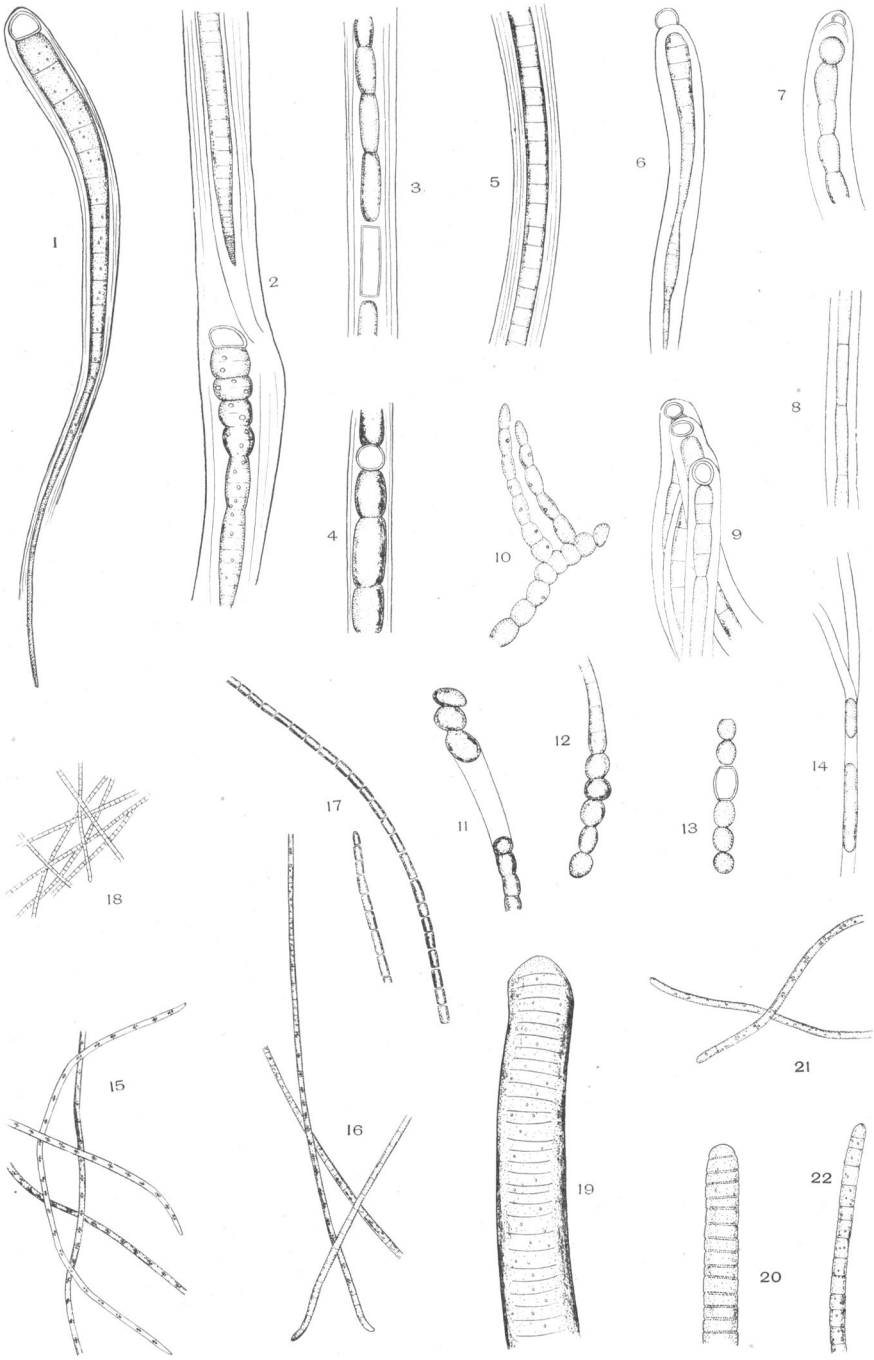
FIGS. 9, 10, 11. *Conferva major* (Kg.) Rabenh. forma *gypsophila*. Filaments giving characteristic appearance of cell wall and cells of different lengths.

FIG. 12. *Microspora amœna* (Kg.) Rabenh. forma *thermalis*. Extremity of filament.

FIG. 13. *Microspora weedii*. Filament showing cell contents and sheath forming "letter H."



TILDEN on THERMAL ALGÆ.



TILDEN on THERMAL ALGÆ.

TILDEN on THERMAL ALGÆ.

FIG. 14. *Rhizoclonium hieroglyphicum* (Ag.) Kg. var. *atro-brunneum.* Filament showing lateral process and disposition of cell contents.

FIGS. 15, 16. Portions of filaments showing appearance of normal cells.

FIG. 17. Portion of filament showing a distorted cell.

FIG. 18. *Protococcus botryoides* (Kg.) Kirchn. forma *caldarius.* Appearance of cells in process of division.

FIG. 19. *Spirulina major* Kg. Portion of filament.

FIG. 20. *Spirulina caldaria.* Portions of filaments.

FIG. 21. *Chroococcus varius* A. Br. General appearance of cells.

PLATE IX.

FIG. 1. *Calothrix thermalis* (Schwabe) Hansg. Young plant entire, showing basal heterocyst and trichome indistinctly septate.

FIG 2. Portion of mature filament with branch. The trichome of branch shows well the moniliform character and granular protoplasmic contents.

FIG. 3. Portion of filament with oblong intercalary heterocyst.

FIG. 4. Portion of filament with spherical intercalary heterocyst.

FIG. 5. Portion of filament with articulations as long as wide.

FIG. 6. *Rivularia hæmatites* (DC.) Ag. Young plant.

FIGS. 7, 8. Mature forms showing moniliform and cylindrical trichomes.

FIG. 9. Branching filament.

FIG. 10. *Hapalosiphon major* Tild. Filament with twin branches.

FIG. 11. Filament showing empty sheath.

FIG. 12. Filament showing both moniliform and cylindrical trichome.

FIG. 13. Filament with heterocyst.

FIG. 14. *Symploca thermalis* (Kg.) Gomont. Filament with pseudobranch.

FIG. 15. *Phormidium laminosum* (Ag.) Gomont. Filaments.

FIG. 16. *Phormidium laminosum* forma *Weedii.* Filaments.

FIG. 17. *Phormidium tenue* (Menegh.) Gomont. Filaments.

FIG. 18. *Phormidium rubrum* Tilden. Filaments.

FIG. 19. *Oscillatoria princeps* Vauch. Apex of filament.

FIG. 20. *Oscillatoria tenuis* Ag. Apex of filament.

FIG. 21. *Oscillatoria amphibia* Ag. Portions of filaments.

FIG. 22. *Oscillatoria geminata* Menegh. Apical end of filament.

PLATE X.

A photograph of Solitary Spring, Upper Geyser Basin, Yellowstone National Park. *Phormidium laminosum* forms a part of the algal growth of this spring.